Grosbras, M.-H., Reason, M., Tan, H., Kay, R. and Pollick, F. (2017) Subjective and neurophysiological perspectives on emotion perception from dance. In: Karkou, V., Oliver, S. and Lycouris, S. (eds.) *The Oxford Handbook of Dance and Wellbeing*. Series: Oxford handbooks. Oxford University Press. ISBN 9780199949298 (doi:10.1093/oxfordhb/9780199949298.013.46)

Subjective and Neurophysiological Perspectives on Emotion Perception from Dance

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Submitted to: The Oxford Handbook for Dance and Wellbeing (2016) – Oxford University Press, Editors Vicky Karkou, Sue Oliver and Sophia Lycouris

Abstract

A prime motivation for engaging with dance can be experiencing emotions with affective qualities being interwoven with aesthetic appreciation. As such, dance can offer a valuable tool for the neuroscientific study of emotion processing.

This idea underpinned some of the activities completed as part of the multidisciplinary project "Watching Dance", which aimed to investigate the neural correlates of the subjective emotional reaction to dance. We invited participants to watch a four-minute long video-edit of a piece of contemporary dance, choreographed for the purpose of the research project, involving two dancers and three different music segments. We measured subjective emotional response by mean of a continuous rating with a slider on an analogue scale. This was complemented by structured interviews prompting the participants to reflect on their ratings. We measured the brain correlates of this response using functional brain imaging; this was complemented with a brain interference study to investigate a causal link between regional brain activity and the subjective emotional response.

Across participants a general pattern of emotional rating emerged that was strongly influenced by both the music and the fluidity of movements, as confirmed by the qualitative investigation. The intensity of the emotional response was negatively associated with activity in brain regions involved in visual perception as well as in the right parietal cortex, a region important for high-level cognitive processing and reasoning. Interfering with neuronal activity in this region had no effect on the average affective response, but it significantly enhanced the rating of the moments eliciting the highest positive judgments.

These results establish a direct link between posterior parietal cortex activity and emotional reaction to dance. They can be interpreted in the framework of a competition between resources allocated to emotion and resources allocated to cognitive functions. They highlight potential use of brain stimulation in neuro-aesthetic investigations and support treatment strategies targeting the parietal cortex to modulate emotional biases in mood disorders.

Key word: human brain, emotion, neuroaesthetic, qualitative research

Introduction

The appreciation of art is a subjective process often linked to emotional/hedonic experiences. Emotional responses have been intensively studied in the measurement of the aesthetic evaluation of art (e.g. Belke, Leder,Strobach, & Carbon, 2010; Daprati, Losa, & Haggard, 2009; Di Dio, & Gallese, 2007; Vartanian, & Goel, 2004). The responses to art that are measured (pleasure and preference) reflect the observer's emotional feelings towards those works of art. The emotions aroused from viewing art are defined as 'aesthetic emotions', and these are claimed to be closely related to artistic appreciation. Positive emotions have been studied most in aesthetic psychological studies, for example pleasure (e.g. Fechner, 1876) and liking (e.g. Belke et al., 2010; Daprati, Losa, & Haggard, 2009; Di Dio, & Gallese, 2007; Vartanian & Goel, 2004). However, some other studies indicate that negative emotions may also be associated with art appreciation, like anger, disgust (e.g. Silvia & Brown, 2007) and hostile emotions (Silvia, 2009). Silvia (2005a, 2005b) introduced an appraisal model of emotions into the psychology of aesthetics, which posits a linear relationship between emotion and aesthetic judgement. Other models take into account a more complex relationship that includes emotional, aesthetic and cognitive appraisal. The "hedonic fluency model" (Reber et al., 2004) claims that the appreciation of artwork is not limited to the perception of object properties, but is also influenced by pleasant feelings arising from the observation of artwork, and is closely related to successful cognitive processing. Leder et al. (2004) suggested that artistic experience may be based on the cognitive interpretation, with processing fluency leading to a feeling of aesthetic pleasure. They proposed an information-processing framework to explain why the appreciation of artwork is always accompanied by affective reactions. This multi-stage model involves different levels of processing: pre-classification, perceptual analyses, implicit memory integration and explicit classification, as well as cognitive mastering and evaluation. Affective evaluation is continuously taking place and impact on the cognitive mastering process at each stage. In summary, according to this model, "An aesthetic experience is a cognitive process accompanied by continuously upgrading affective states that *vice versa* are appraised, resulting in an aesthetic emotion" (Leder et al 2004, p 493).

These models are supported by studies in the Arts and Humanities, which have investigated appreciation and emotional responses. Considering the complexity of emotional reaction to art appreciation, qualitative research methods are often important approaches to understand subjective feelings and audiences' individual experience involved in the appreciation process (Reason & Reynolds 2010). Neuroscience research has also started to shed light on the brain and body correlates of the arts appreciation and in particular the emotions evoked by arts, leading to the emergence of the field of Neuroaesthetics (Di Dio & Gallese 2009). This research indicates that a network of brain structures involved in emotional processing is also associated with artistic appreciation. These regions include the left anterior cingulate sulcus (see Devinsk, Morrel & Vogt, 1995 for a review), the insula and the amygdala (Phelps & LeDoux, 2005; Cupchik, Vartanian, Crawley & Mikulis, 2009, also see Di Dio & Gallese, 2009 as a review), the ventromedial frontal cortex (Calvo-Merino et al., 2005). Theses regions are activated in addition to regions involved in object or person perception in visual and premotor cortices (Calvo-Merino et al. 2007).

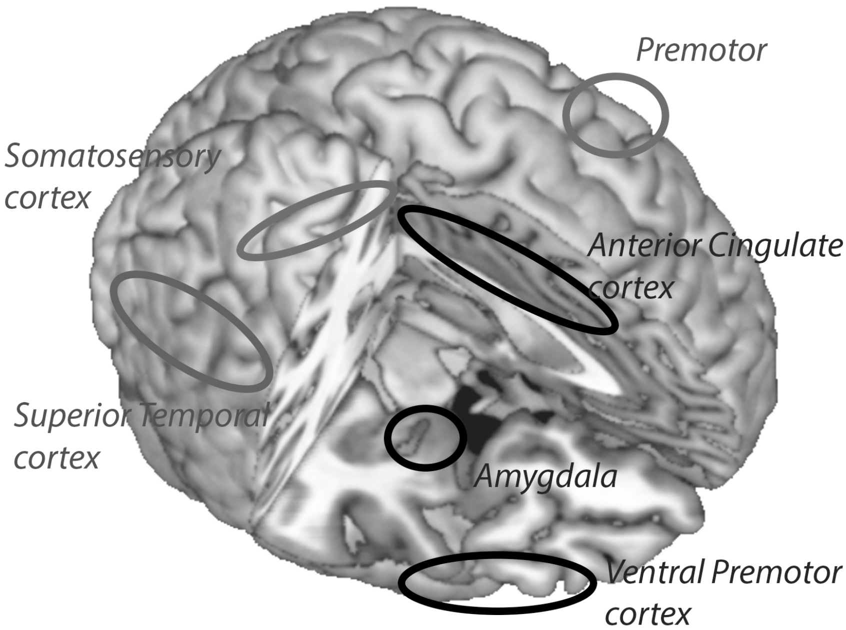

Figure 1. Network of brain structures involved in emotional processing and artistic appreciation. In black, regions commonly involved in emotion processing and in grey regions commonly involved in person perception.

Empirical and theoretical work from all these fields of research (psychology, neuroscience and qualitative audience research) support the idea that aesthetic experience is a complicated psychological state that involves multiple cognitive approaches, while emotional responses evoked from the experience are especially apparent and intermingled with different cognitive processes. In this context, the present study aims to provide a multidisciplinary account of the emotional response to dance. To this end we combine psychophysics, brain measures and qualitative research to study the subjective emotions induced by watching dance. The originality of this approach offers a unique view of emotional engagement with dance, which could form the base for more applied research on dance as a mean of regulating emotions. Part of the data on which this paper is based has been published as a scientific report (Grosbras, Tan & Pollick, 2012).

Dance is an art form that uses the dancer's body as a means to induce affective and aesthetic experience in the observers. It has been used in the field of qualitative audience research but also in Psychology and Cognitive Neuroscience as a form of stimulus to study emotion perception (see also Blasing's chapter in this volume). Macfarlane, Kulka & Pollick (2004) asked subjects to rate emotional valence after watching ten pieces of dance with different affects and found that subjects were able to accurately distinguish the emotion portrayed by the dancers. This study, however, involved segments of dance, each 15-seconds long, with judgements of affective similarity made *after* the presentation of the videos. Yet emotional response to dance occurs in the immediacy and evolves as the dance performance unfolds (Jola, Reason, Pollick & Grosbras 2012). Thus in the present study we collected continuous ratings on a linear visual scale. Participants watched a four-minute long video constructed from the filming of a piece of contemporary dance choreographed for the purpose of the research project (Watching Dance, www.watchingdance.org , involving two dancers and three different music segments. They were asked to use a computer mouse to move a slider on a screen upwards when they felt positively aroused and downwards when they felt a negative emotion. This provided us with a continuous rating of their subjective emotional response. We chose to focus only on valence and intensity rather than categorization of individual emotions (e.g. sadness, joy, fear, etc) as those dimensions capture most of experience of emotion and are less sensitive to interindividual differences in labelling feelings and emotions. Indeed based on the circumplex model of affective experience, one of the most influential models in the field of emotion research (Russel, 1980), each emotion can be placed on a plan with the two bipolar dimensions representing valence (or pleasantness: positive or negative) and arousal (or activation: low or high). Importantly both dimensions are independent and correspond well to the conscious experience or perception of emotion (Pollick, Paterson, Bruderlin, & Sanford, 2001). While previous studies have collected only self-reported positive emotion responses to dance, In reference to this model, we felt that using a bipolar slider i.e. measuring not only positive but also negative emotional changes was pivotal. Similar ratings of the aesthetic response were also obtained in order to test the relationship between affective and aesthetics impressions during the continuous watching.

We used these ratings to investigate how the subjective judgement of the emotion induced by the dance modulates the brain response to the dance. To this end we used functional magnetic resonance imaging (fMRI), a technique that provides us with an indirect measure of brain regional activity, exploiting the fact that brain regions that are active receive an increased afflux of oxygenated blood, which in turn changes the magnetic signal in a way that can be measured. We relied on a parametric approach (Buchel, Morris & Dolan, 1998) to map the impact of emotion on the regional neuronal activity.

This experiment was complemented by two lines of investigation. First, in order to draw causal links between the identified functional brain regions and emotional appraisal, we conducted a non-invasive brain interference study using Transcranial Magnetic stimulation (TMS). Indeed fMRI shows where in the brain the activity is *correlated* with the perception of dance while subjects are watching the video. It does not tell us anything about the causal nature of this relationship. TMS is a technique that allows us to transiently and non-invasively perturb local brain activity (review in Walsh & Ruschworth, 1999) If as a result we observe a change in behaviour, then we can infer that the brain region targeted with TMS is causally involved in the behaviour under investigation, and not just incidentally activated. It works by applying a rapidly changing focal magnetic field near the scalp of the participants, which depolarizes the nearby neuronal populations and thereby interfere with their activity. If applied repeatedly during several minutes the effect of altered activity can outlast the stimulation by 10 to 15 minutes. In this study we used TMS to ask whether a small and transient manipulation of the regions identified in fMRI could modify the emotional appreciation of dance. Second we conducted a qualitative investigation probing participants' subjective reflections on their reaction to the dance, in order to get further insight into the meaning of their responses during the experiments.

In summary, the aim of this project was to investigate the neural correlates of the subjective emotional reaction to dance, using functional brain imaging and non-invasive brain interference to investigate a causal link between regional brain activity and the subjective emotional response. This was complemented by structured interviews prompting the participants to reflect on their ratings. This chapter will present and discuss some of these findings with regards to their relevance for understanding the links between emotion and cognition. In doing so we will draw link with wellbeing. For the purpose of this chapter wellbeing will be seen as a state of health and positive functioning and we will argue that it is strongly dependant upon the harmonious integration between cognitive and affective processing at the brain level. We will speculate about how considering dance perception in this framework could offer new research avenues for interventions promoting wellbeing.

Methodology

2.1 Subjects

Thirty-two subjects from Glasgow University participated in this study. Sixteen (8 females) took part in the first (FMRI) as well as in the third part (structured interview) and sixteen other in the second part (TMS). They were recruited from adverts throughout the University and were all naïve to the purpose of the study and had no experience in any dance related activity in the past year. They all had normal vision and had no past neurological or psychiatric history. The study was approved by the Ethics Committee of the College of Science and Engineering, University of Glasgow. Written informed consent was obtained from all subjects prior to inclusion in the study.

2.2 Experiment Stimuli

The stimulus material was a 3-minute-and-38-second edited video (25 frames per seconds) of a contemporary dance involving two dancers (one male, one female) with strong physical body movements (see Figure 2 and video on the online version of the book). The dance was produced for the Watching Dance project (www.watchingdance.org) as part of a collaboration with the Rosie Kay Dance Company. The original dance was over 20-minutes long and comprised the same five-minute dance performed three times to different soundscapes (mechanical soundtrack with breathing sounds of the dancers, dance music and Bach concerto) as well as separate introductory and concluding segments. Cameras recorded the dance performance from different angles. The final video was the result of an independent editing and comprises a collection of excerpts from the original dance that included different camera angles and different soundscapes .

Figure 2. Snapshots from the video showing moments described as synchronous (left) and asynchronous (right). Double Points: 3x, Rosie Kay Dance Company, dancers Rosie Kay and Morgan Cloud. Photographer: Brian Slater.

2.3 Functional Brain Imaging methods

2.3.1 Procedure

Participants watched the dance video in the Magnetic Resonance Imaging (MRI) scanner, and gave their emotional and aesthetic ratings afterwards. At the time of scanning, subjects were not aware of the questions in the later behavioural tests and were instructed to passively view the dance performance. No task was used in order to avoid cognitive influences during scanning.

2.3.2. Post scanning data

After the scanning session, subjects were taken to another room and the dance video was re-shown to them twice. A slider was showed on the right side of screen while video was played. The sliders were bipolar. The ratings ranged from -230 to +230 pixels but no number was shown on screen to indicate the scale; only the zero point was shown in the middle of the slider. Participants were instructed to move the mouse to indicate their emotional response to the dance performance continuously as often as possible. Upper means more positive emotional feeling while lower means more negative feelings. Subjects were instructed to make their ratings as close as possible, in accordance with their experience during scanning. The same procedure was repeated, asking participants their aesthetic judgement: "*This time you are going to be reporting the aesthetic experiences you have while watching the same movie. You will be reporting them using a mouse working as a slider. We define aesthetics as 'the extent to which the movie is appealing to you, or* *how much intellectually engaging it is.' Move the mouse up if you feel that it is very appealing/intellectually engaging) or down if you don't think so*."

2.3.3 Functional brain imaging (Scanning)

Brain activity was recorded on a 3 Tesla Tim Trio Siemens scanner (Erlangen, Germany). The video was projected on a translucent screen positioned at the back of the scanner and which the subjects could see thanks to a tilted mirror. The sound was diffused via a pneumatic audio system with earplugs. Functional scans consisted of 117 full-brain volumes acquired one every two seconds at a resolution of 3x3x3 mm. At the end of the scanning session, high-resolution (1X1X1 mm) structural image was collected, which we used to localize the brain activity on brain anatomy.

Participants were instructed not to move the body and head during dance presentation.

2.3.4 Image Analysis

Analysis was carried out using the FSL suite (fmrib.oxford.ac.uk). First standard preprocessing was applied, including correction for small head movements and drifts and spatial smoothing. Then we estimated, at each voxel in the brain the correlation between the fMRI time series and the slider data. To this end the slider data were normalized and resampled to 2-seconds time-bins to match the fMRI time-series (for which one full-brain image was acquired in 2 seconds). This resulted , for each individual, in a correlation brain maps, showing at each element of the brain image (i.e each voxel) the correlation coefficient. These maps were transformed into a common standard space so that data from all participants could be compared and averaged. Group results maps indicate where in the brain the neuronal activity is related consistently to the *a-posteriori* emotional judgements. To identify the regions with the most significant correlation between activity and judgment we applied a threshold to retain only clusters of activity with a significance of P=0.05 (Worsley et al 2005). We looked at both positive and negative correlations. In addition we performed a second analysis to identify brain regions related to intensity judgement, i.e. high or low emotional engagement either positive or negative. To this end we took the absolute values of the slider data and performed the brain-behaviour correlation analysis as described above. The aesthetic judgements data were analysed in the same way.

2.4 TMS Method

The TMS experiment was carried out on a separate group of participants, targeting the brain region identified in the fMRI group analysis as showing the most significant and meaningful correlation between neural activity and emotion. This was done by transforming the coordinates of this region –

identified in the group-- into each individual brain space and using a dedicated system to place the TMS coil over this location.(see Figure 3). We applied TMS for 15 minutes at 60% of maximum stimulator output, while continuously monitoring coil position and eventually adjusting it. Stimulation was delivered by a Magstim rapid-2 stimulator (Dyfed, Wales) through a 7-cm diameter figure-of-eight coil. Following the TMS session, participants took the subjective slider rating task as described in *the fMRI procedure*. In a separate session we stimulated the vertex as a control where no effect was expected. Both sessions were completed on the same day and were separated by at least 40 minutes. The order of the sessions was counterbalanced. Subjects wore commercial earplugs to attenuate the noise from TMS stimulator.

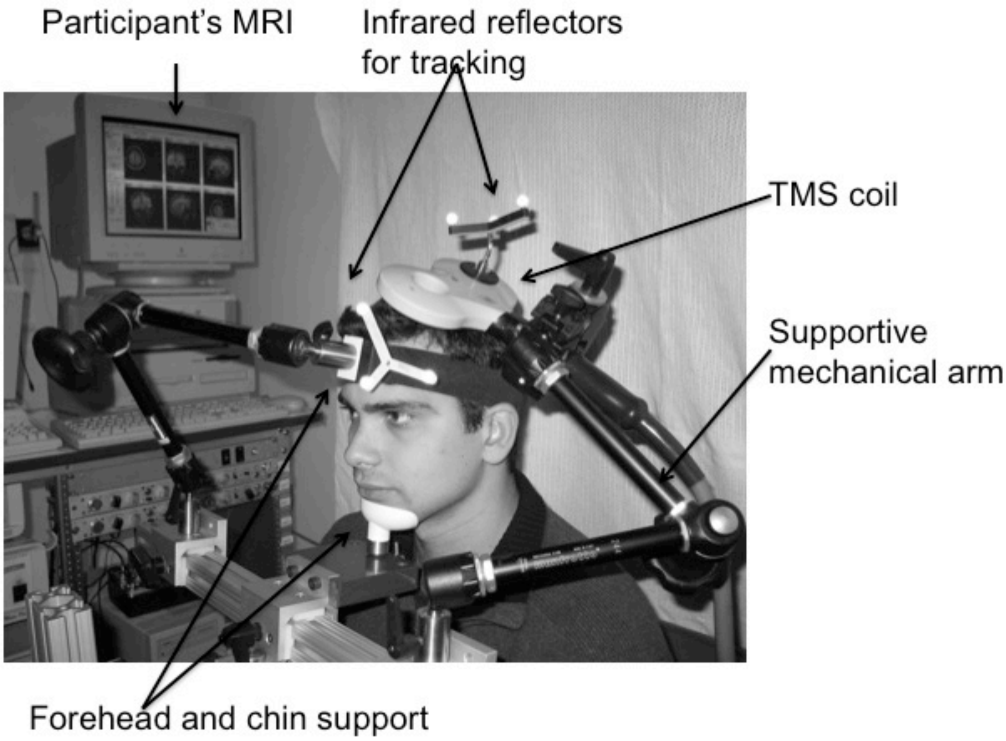

Figure 3: Photo of set up for the transcranial magnetic stimulation (TMS) experiment. Participants are seated on a comfortable chair and chin and forehead supports help them maintain their head still during the 15 minutes stimulation. A camera system tracks infrared landmarks attached to the head and the TMS coil and allows us to track the position of the stimulation relative to the brain MRI of the participant.

We performed two analyses to compare the continuous ratings following active or control TMS. First, we analysed the entire duration of the slider data by computing the mean and standard deviations, and compared the control and the active TMS conditions. We ran a separate analysis of variance for each of these measures to compare their values in the two TMS conditions (repeated factor). To take into account the effect of exposure we also added a between subject factor to compare the TMS effect in the group of participants who received parietal TMS first with those who had control TMS first.

Second, we did time-wise analysis to examine any TMS effect at specific moments of dance (Blair et al 1993). We first resampled the data into 722 time points. This is used for smoothing data and limiting computation. Then, at each time point we performed a paired *t-test* across all the participants on each subject's parietal TMS condition and control condition.

To assess at which time points the t-value was significantly different from 0, we built a distribution of t-statistics by randomly permuting the sign of the t-values (under the null hypothesis the values obtained for each subject are interchangeable and thus the sign of the difference is also changeable). For each permutation we extracted the maximal t-value (Tmax) across the timeseries. We built a distribution of Tmax for 10000 permutations. To conduct two-tail tests while controlling for multiple comparisons we determined the t-values that cut the Tmax distribution at 0.025 on each tail and compared each of the 722 values of the original t-test to these values to determine significance at $p<0.05$. In addition we repeated the procedure to compare the groups of participants who had control TMS in the first or second session and assessed whether the effects qualified as significant were higher than those due to multiple exposures.

2.5 Qualitative Methods

Semi-structured one-on-one interviews took place with 12 of the 16 subjects who participated in the fMRI experiment a few weeks after the initial testing. The interviews began with participants watching the same 3 min 38 second video that they had watched in the scanner. They were then invited to talk freely about the video recording before being shown their individual slider charts with the 'aesthetic' and 'emotional' responses that they had indicating using the slider and in response to the instructions. The participants were invited to interpret their own slider charts, reflecting upon the significance of the highs and lows and on the relationship with the video performance (which included going back to the recording, sometimes several times, to try to match a moment on the slider to a moment in the dance). Participants were also asked to comment on how they had interpreted the instructions when using the slider.

The interest was in the participants' conscious reflection upon their own experience, and on using this to trace the relationships and divergences between emotional and aesthetic responses to watching the video performance. Located within the traditions of qualitative audience research, this approach was concerned with individual responses to the particular performance seen and in the ways in which individuals make sense of experiences for themselves both in the moment of watching and after the event.

One of the primary objectives of all qualitative audience research is to elicit talk from participants, providing circumstances where they can respond to their experiences in their own words and in an open manner (see for example Barker 1998; Geraghty 1998). On this occasion this approach was adjusted to take into account the collaborative process with the neuroscience research, the nature of the stimulus being used (most audience research uses real world stimulus, performances in theatres, very different from a short edited video recording) and in particular the use of slider measurements.

For these reasons the decision was made to focus the interviews around these aesthetic and emotional responses and, moreover, to do this through showing the participants their own slider chart results and invite them to help us analyse the graphs. With the video recording on a laptop the participants were able to watch and rewatch the recording, matching moment on the slider chart and conscious reflecting on the responses and feeling that each moment elicited.

This approach was motivated by the ethos of participatory inquiry and action research, methodologies that seek to engage participants as active co-researchers in a process that acknowledges their own self-reflective expertise in their own perception and experiences. Creswell describes the participatory worldview as one that sees meaning as “constructed by human beings as they engage with the world they are interpreting” (2009, p. 9). Of course, within this perspective the nature of that ‘expertise’ is uncertain. For example, was the participants’ operation of the sliders an instinctive and unreflective response to a stimulus or a more or less conscious process of reflective meaning making? Equally the relationship between the participants’ understanding of how and why they responded in that moment when asked a couple of weeks later is unclear. Nonetheless, these very gaps and uncertainties are potentially valuable when considering what we mean by emotional and aesthetic responses to art. The slider charts produce moment by moment responses, produced in response to particular instances in the video and moreover influenced by what had just gone before. It is possible to argue that in contrast an aesthetic consideration requires some sense of overview and reflective distance. Responses to art, in other words, are produced both in the moment of watching but also through reflective consideration (Reason 2010). This perspective also draws of ideas of social phenomenology, where Alfred Scultz writes that

> Meaning does not lie in the experience. Rather, those experiences are meaningful which are grasped reflectively. [...] It is, then, incorrect to say that my lived experiences are meaningful merely in virtue of their being experienced or lived through.[...] The reflective glance singles out an elapsed lived experience and constitutes it as meaningful. (Schutz 1967: 67-71)

We might argue rather that meaning is produced through both affective and reflective processes (Sobchack 2004: 75). In the context of this research the participants were therefore being asked to reflect upon their immediate responses and to consider what meanings could be constructed from them and through them.

Results

3.1 Behavioural results

Ratings of the two groups of participants (fMRI and TMS) are represented on figure 4, showing no significant differences between groups. Despite some inter-individual variability, a general pattern emerged with globally the first half of the performance being linked to negative emotion and the second half to positive emotion, with higher ratings on the positive side of the scale. On the average and in most individual participants, clear transitions could be observed at the moments when the music changed.

The aesthetic judgments acquired in the group of subjects involved in the fMRI experiment, showed less amplitude and more variability than the emotional judgements. On individual level, significant correlations between the aesthetic ratings and emotion ratings were shown in fifteen subjects of all the sixteen subjects ($p < .01$). At the group level, the rating of aesthetics (means ± SD) averaged from all subjects was 67.8 ±27.193 and the rating of emotion was 47.16 ± 67.045 (see fig. 2). We observed also a significant correlation between aesthetics and emotion (Pearson $r = .661$, $p < .01$).

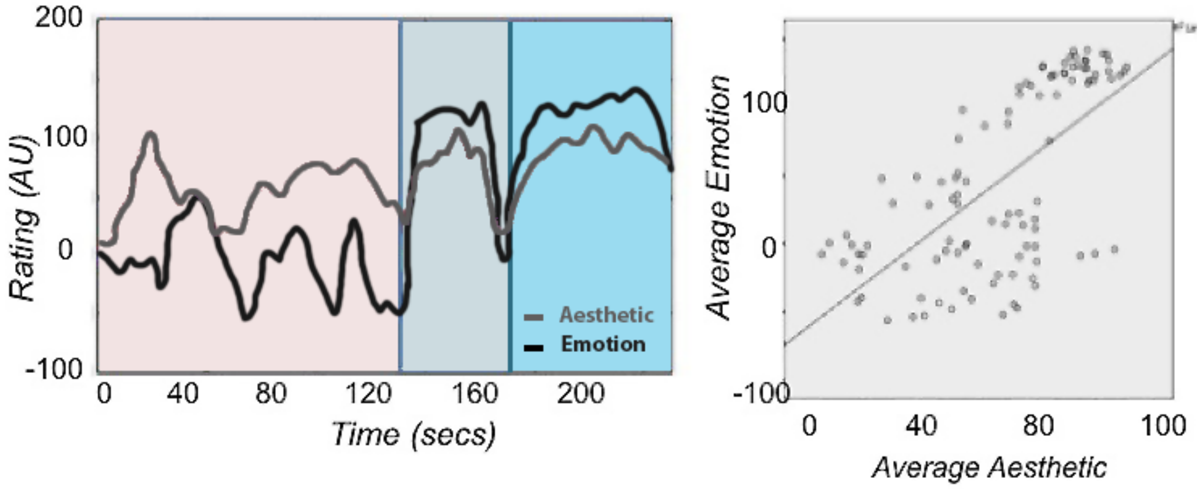

Figure 4. *Left.* Averaged slider ratings over time on the "emotion" (black) and "aesthetic" (grey) scales. The shades underline the three sections of the video corresponding to the three different soundtracks. *Right.* Moment by moment correlation between the emotion and aesthetic ratings, computed on 10-seconds time bins.

3.4 Qualitative results

The observation from the slider data were largely corroborated by the interviews analyses, although talking to individual participants inevitably complicates the picture. Rather than engaging with averages, qualitative audience research reveals the details of individual responses – which are often heterogeneous and idiosyncratic and are strongly linked to participants' previous experiences and attitudes. Following Pierre Bourdieu (1984), qualitative audience research has explored the importance of previous experience and cultural capital in shaping an individual's taste and their engagement with art. The focus of the research in this instance was directed by the use of the emotional and aesthetic questions in the slider task.

In the interviews the majority of the participants used the music as the main reference point through which to talk about different sections of the video and to segment the performance. Equally their comments suggested that, while watching, the music significantly shaped and directed their responses. Commentators have described how the lived experience of both music (Barthes 1986) and dance (Sheets-Johnstone 1979) are challenging, or even impossible, to put into language. In this instance as our participants were inexperienced dance audiences, we may speculate that music represented a more familiar experience and therefore one where they were more able to articulate their experience.

In their responses, and therefore also in this discussion, the video-edit is divided into three broad sections, as defined by the sound score. Firstly, a 'mechanical' or 'industrial' music section, which was the least homogenous of the sections in terms of both the soundscape and the movements; second a 'dance' or 'electro' music section; third a 'classical' music section. The last two sections were conceived as more homogenous and more similar, both internally and in relation to each other. Between the second and third sections there was a short but clear and very widely perceived visual and sonic break that was noted by all the participants (140-154 on the time scale).

The first section was labelled by the participants as emotionally dark or negative (variously described as 'weird', 'sinister', 'scary', 'odd', 'aggressive' and 'uncomfortable'). Participants described this negative emotion as 111predominantly produced by the music, which during this section was mechanical, industrial, 'strange'. A secondary factor was choreographic movements, which were characterised by a lack of touching between the two dancers, oppositional facing-off across a dividing line and more extreme or unusual body posture.

The second and third sections in contrast were perceived as an emotional high, particularly after this dark first section. These sections were marked by a more familiar style of music (respectively dance and classical) which brought in a higher tempo and a greater sense of sonic fluidity and flow. Choreographically the dancers also began moving more together, in synchrony, touching more and being closer. Both sections two and three were described as having more harmony between the music and movement, which was related to a positive emotional response (and, as will be discussed, also a positive aesthetic response).

Between sections 2 and 3 was a short, darker moment, marked by a soundscape of high pitched whistling and a particular choreographic and screen focus on the dancers' feet, tiptoeing round each other. This short section was often very visibly noticeable on the slider charts as a sharp and significant downward spike and therefore when looking at these charts the participants were drawn to it and to the reflective task of identifying what had caused it. In this instance they found it easy and satisfying to match their reflective evaluation of their response to the slider data – they in a sense 'knew' what had been going on for them in that moment.

Overall in terms of emotional responses there was a strong similarity between the respondents, 9 out of the 12 participants strongly matched the pattern described above. This level of consistency would suggest that the participants were largely drawing their emotional interpretations from the recording (as opposed to what they brought to the experience) and that the music in particular was strongly coded in a culturally shared and broadly accessible manner.

It is valuable here to remember that the participants in this research were all inexperienced dance spectators and to interpret their responses in the light of this. In particular their responses match the description of Reber et al where for novice spectators (and in contrast to expert or experienced spectators) positive aesthetic evaluation is associated with more familiar stimuli that can be interpreted with greater processing fluency (2004: 374). Greater experience and exposure to the arts increases the ability to interpret complex stimuli with fluency and also to impose external judgements about taste, aesthetic and value upon the performance (Bourdieu 1984).

The three exceptions to the typical interpretative pattern that were observed illustrate this in different ways, with in each instance participants' overlaying their own individual tastes onto the experience – in other words the three exceptions are instances where participants' judgements of aesthetic value dictated their emotional responses (Reber et al 2004). One participant, for example, shared the group emotional responses to parts 1 and 2 but had a negative emotional response to the third section. She reported this was because it reminded her of ballet and she didn't like that kind of music or dance. Another fitted the group responses to parts 2 and 3, but also had a positive emotional response to a section of part 2. She reported this being because she had liked identifying and enjoying the 'bird like' movement in that section. The third exception was almost a reversal of the group response, which was directed by her liking the 'newness' of the first section over the known and 'boring' quality of the second two.

In different ways these three responses are directed by an aesthetic or interpretative position. The participants are activating personal taste or attitude and in doing so marking a more assertive individual ownership of their experience

3.2 fMRI results

In the "valence" analysis –looking at where in the brain the activity was related to the positive or negative affective evaluation--, we observed no significant positive correlation. We observed significant negative correlation in bilateral occipito-temporal and fusiform cortex, regions known to be involved in high-level visual processing of objects, faces and bodies. That means that there was more activity in these regions when the dance was perceived the less positive. In the "intensity" analysis – using the absolute value of rating used as predictors--, we observed positive correlation in early visual cortex only (Figure 5). Negative correlation was observed in occipito-temporal and fusiform cortex , as well as in the right parietal cortex. In contrast the same correlation analysis run using the aesthetic judgments results revealed brain activity in a small set of regions, that are known to be involved in attention orienting, including the anterior cingulate cortex, the precuneus and basal ganglia.

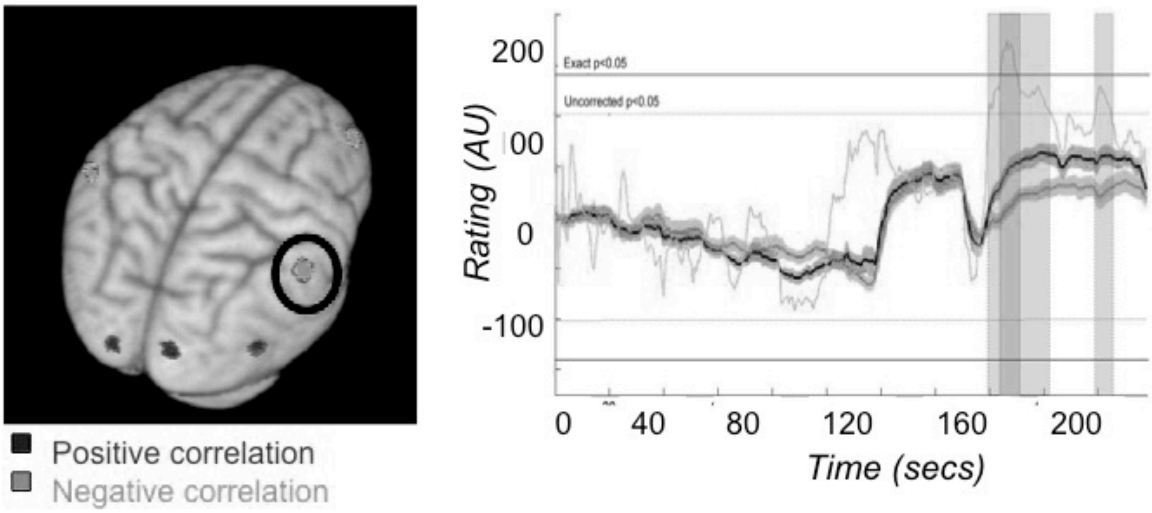

Figure 4. *Left*: Brain regions showing significant correlation between absolute values of emotional ratings and brain activity. Individual correlation maps were computed with individual ratings and not the average rating; the maps were then averaged across the 16 participants. Dark grey spots: positive correlations; Light grey spots: negative correlations. The circle indicates the site of TMS. *Right:* TMS results: averaged (n=16) Zscored ratings after parietal (black) or control (grey) rTMS +/- standard errors and difference (paired t-statistic; pale grey) computed at each time points between the two time-series. Horizontal lines represent the threshold t-value (dotted line) or exact threshold t-value (plain line) for $p<0.05$. Grey area represents regions of the curve showing statistical significance using non-corrected (light grey) or exact t-test (darker grey).

The significant negative correlation between subjective affective ratings and activity in the posterior parietal cortex is reminiscent of reports of decreased activity in “cognitive-control” regions during emotional perception (Drevets, & Raichle, 1988, Greene et al 2001). We thus characterized this region further using meta-analytical tools. We searched the Brain Map database (a repository of brain imaging results from over 3000 experiments; see http://brainmap.org/scribe/index.html) and identified 259 brain imaging experiments reporting brain activation in a 1000 mm^3 region around the peak identified in our analysis. The majority of them (64 %) belonged to the Cognition domain, 28 % to Perception, 15% to Action and 2% to the Emotion domain. Thus this confirms that this region, which is more active when the subjects feel neutral emotionally than when they feel engaged positively or negatively, belongs to the “cognitive” brain network (that is the circuit of brain regions engaged during cognitive tasks) and not the “affective” brain network (that is the circuit of brain regions that are engaged when we experience a strong emotion see Figure 1).

3.3 TMS results

When we transiently interfered with the activity of this region in the parietal cortex, using low-frequency rTMS, we observed no effect on the global average or variance of raw data, nor global average of absolute data (paired t-tests all $p>0.3$). There was also no effect of order of neither viewing, nor interaction between TMS condition and order. In the time-specific analysis, in contrast, we identified only one segment of the dance for which the emotional judgement significantly differed after parietal TMS compared to control TMS, independently of stimulation order: the positive judgement occurring in the last third of the dance-video was rated as eliciting more positive emotion after parietal TMS. It is in this part of the dance-video that the music changes to classical music.

Discussion

Our results from different methodological approaches converge in showing that emotional responses are an important part of the aesthetic experience and are linked to reduced activity in brain networks involved in cognitive control. The experience of emotion was largely shared between participants and was strongly influenced by the music score as well as the "harmony" or fluidity of accord between movement and music. The video editing might have further enhanced this, by juxtaposing excerpts from different visual angles.

Here the qualitative audience research suggested more similarities and shared responses in terms of the emotional responses; and more divergent responses in participants' aesthetic interpretations. This is likely to be because the emotional responses are affects produced in direct response to the stimulus, while the aesthetic responses are more interpretative and learnt. In this particular instance the primary factor shaping emotional and interpretative responses to the recording was reported to be the music.

The findings of this study are partially consistent with theories underlying that the subjective assessment of the aesthetic value is influenced by affects evoked from the work of art, and that the aesthetic judgment has a linear relation with emotion in general. Moreover, the implications of our results are especially in accordance with the Reder et al. (2004)'s model suggesting an interplay between affective feeling and cognitive control. In this model affective evaluation takes place continuously, influencing and being influenced by all stages of cognitive processing occurring during the aesthetic experience.

Our brain imaging results are also in line with this model. They further indicate an antagonistic interaction between processes involved in cognitive reasoning and processes involved in affective reaction. Indeed the higher the subjective emotional rating of the dance, the less activity was shown in regions important for reasoning and action control, in particular in the region of the parietal lobe that we targeted with TMS. Beyond a simple correlation between an index of neuronal activity in this region, we also show that decreasing activity there can indeed cause an increase in subjective emotional judgement. This effect was dependent on context, occurring only for the part of the dance that was judged the more emotional, with increased fluidity and harmony. This is in accordance with the idea that resources engaged for emotion and executive control, respectively, can compete in some contexts. Indeed, while traditionally the affective and cognitive systems have been considered as separate, independent entities, at the conceptual as well as at the neurophysiological level of analysis, it is increasingly recognized that the interaction between the two systems is at the core of a large part of our behaviours (Damasio, Pessoa, 2008, 2010). The expansion of Cognitive Neuroscience has contributed significantly to this paradigm shift across disciplines by allowing researchers to characterize the networks of brain areas involved in emotion and cognition, respectively, as well as their interactions. Such interactions are reflected by areas of overlap as well as antagonistic functioning. Brain imaging studies have shown that regions involved in executive or cognitive control are less active and when regions involved in emotion processing and perception are engaged and *vice versa* (Mitchell et al 2006, Greene et al 2001, Drevets et al 1993). Importantly disruption of the harmonious integration between the control and affective system is associated with a manifold of mental disorders (Cole, Repovs& Anticevic, 2014). Therefore understanding this interaction, in different contexts, offers some leverage to research novel intervention approaches that could restore normal integration between cognitive and affective processes. In this regards our observation that a small manipulation of one node of the cognitive control network can change subjective emotional report open interesting perspectives.

Another important result from both the qualitative and the quantitative measures is that positive emotional responses were more strongly held than negative emotional responses. Indeed this is where the greatest consistency emerged. It is also the part of the judgement that could significantly be modulated by bringing down brain activity in brain networks involved in cognitive reasoning. This has also important implications to foster research on potential health benefit of watching dance. Indeed mental health and wellbeing are deeply interconnected with the ability to experience positive emotions (Fredrickson& Joiner 2002). Identifying what specific aspects of music/movements enhance the evoked positive feeling would be beneficial for therapies.

Conclusions

Our study suggests that the sense of harmony and fluidity are important for inducing positive affect. Moreover, our results show a direct relation between these evoked positive emotions and brain activity in specific networks. So far emotional well-being has been mainly related to activity in prefrontal regions of the brain. Non-invasive brain stimulation targeting these prefrontal regions can influence emotional judgements of ambiguous stimuli (Donhauser et al 2013) as well as response biases (Van Honk et al, 2002, Schutter et la 2001). Moreover rTMS is used clinically for depression or anxiety disorders treatments (reviewed in George 2013). Our study adds to this research field by showing that activity in the parietal cortex could also modulate subjective positive feeling when watching dance. Importantly lowering activity in this region led to enhanced judgments of the dance segments that were experienced positively. This highlights the contextual nature of the effects observed using these techniques. In terms of implications, it would be interesting to explore new therapeutic avenues for affective disorders. Indeed TMS has been successfully used in combination with behavioural therapy for motor rehabilitation (Liew et al 2014). Similar combined approaches could be envisaged for treatment of affective disorders, which would involve simultaneously inducing aesthetic emotions by the means of art and brain manipulation to facilitate those effects.

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